

US Patent Application No. 10/666,354
Reply to Office Action of March 1, 2006

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Original) A method of lowering the dielectric constant and increasing the thermal stability and mechanical stability of a low k dielectric layer on a substrate, comprising:
 - (a) providing a substrate;
 - (b) forming a low k dielectric layer comprised of an organosilicon material on said substrate;
 - (c) performing a first treatment comprised of He plasma on said low k dielectric layer in a process chamber to form a transformed low k dielectric layer; and
 - (d) performing a second treatment comprised of H₂ plasma on said transformed low k dielectric layer in a process chamber.
2. (Original) The method of claim 1 further comprised of curing the low k dielectric layer before performing the He plasma treatment.
3. (Original) The method of claim 1 wherein the low k dielectric layer is comprised of carbon doped silicon oxide, hydrogen silsesquioxane (HSQ), or methyl silsesquioxane (MSQ).
4. (Original) The method of claim 3 wherein said carbon doped oxide layer is SiCOH with a composition of about 15-18 atomic % Si, about 28-30 atomic % oxygen, about 16-18 atomic % carbon, and about 36-38 atomic % hydrogen.
5. (Original) The method of claim 1 wherein the first and second treatments are performed with a plasma enhanced CVD (PECVD) process.

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6. (Original) The method of claim 1 wherein said first and second treatments include a gas flow rate from about 1500 to 6000 standard cubic centimeters per minute (scm).
7. (Original) The method of claim 1 wherein the first and second plasma treatments are each performed during a period of about 10 to 360 seconds.
8. (Original) The method of claim 1 wherein the process chamber pressure during said first and second treatments is between about 1 mTorr and 20 Torr.
9. (Original) The method of claim 1 wherein the He plasma in said first treatment and the H₂ plasma in said second treatment is generated by applying a RF power between about 300 and 2500 Watts.
10. (Original) The method of claim 1 wherein said substrate is heated between about 100°C. and 500°C. during said first and second treatments.
11. (Original) The method of claim 1 wherein said second treatment is performed in the same process chamber as said first treatment without breaking a vacuum between the two treatments.
12. (Original) The method of claim 1 wherein the transformed low k dielectric layer has a top portion that becomes enriched in Si-H bonds during the H₂ plasma treatment.
13. (Original) A method of lowering the dielectric constant and increasing the thermal stability and mechanical stability of a low k dielectric layer in a damascene process, comprising:
 - (a) providing a substrate having an etch stop layer formed thereon;
 - (b) depositing a low k dielectric layer comprised of an organosilicon compound on said etch stop layer;

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(c) performing a first treatment comprised of He plasma on said low k dielectric layer in a process chamber to form a transformed low k dielectric layer;

(d) performing a second treatment comprised of H₂ plasma on said transformed low k dielectric layer to form a composite low k dielectric layer comprised of a transformed low k dielectric layer that is enriched in Si-H bonds on a transformed low k dielectric layer that has a mechanically stabilized network of Si-O bonds;

(e) forming an opening in said composite low k dielectric layer that extends through said etch stop layer; and

(f) depositing a diffusion barrier layer on the sidewalls of said opening, depositing a metal layer on said diffusion barrier layer that fills said opening, and planarizing said metal layer and said diffusion barrier layer to a level that is coplanar with said composite low k dielectric layer.

14. (Original) The method of claim 13 further comprised of curing the low k dielectric layer before performing the He plasma treatment.

15. (Original) The method of claim 13 wherein the low k dielectric layer is comprised of carbon doped silicon oxide, HSQ, or MSQ and has a thickness between about 1000 and 10000 Angstroms.

16. (Original) The method of claim 15 wherein the low k dielectric layer is a carbon doped silicon oxide layer which is SiCOH with a composition of about 15-18 atomic % Si, about 28-30 atomic % oxygen, about 16-18 atomic % carbon, and about 36-38 atomic % hydrogen.

17. (Original) The method of claim 13 wherein said first and second treatments each include a gas flow rate from about 1500 to 6000 sccm and have a duration from about 10 to 360 seconds.

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18. (Original) The method of claim 13 wherein the process chamber pressure during said first and second treatments is between about 1 mTorr and 20 Torr.
19. (Original) The method of claim 13 wherein the He plasma in said first treatment and the H₂ plasma in said second treatment is generated by applying a RF power between about 300 and 2500 Watts.
20. (Original) The method of claim 13 wherein said substrate is heated to a temperature between about 100°C. and 500°C. during said first and second treatments.
21. (Original) The method of claim 13 wherein the transformed low k dielectric layer enriched in Si-H bonds has a thickness from about 1000 to 3000 Angstroms.
22. (Original) The method of claim 13 wherein said first treatment is performed in the same process chamber as said second treatment.
23. (Original) The method of claim 13 wherein the diffusion barrier layer is comprised of one or more of Ta, TaN, TaSiN, Ti, TiN, W, or WN and the metal layer is copper.
24. (Original) A method of lowering the dielectric constant and increasing the thermal stability and mechanical stability of a low k dielectric layer in an interconnect structure, comprising:
- (a) providing a substrate with a metal layer comprised of metal lines having a top surface and sidewalls formed thereon and an anti-reflective coating (ARC) formed on the top surface of said metal lines;
 - (b) depositing an oxide layer comprised of one or more conformal oxide layers on said substrate, on the sidewalls of said metal lines, and on said ARC;

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- (c) depositing a low k dielectric layer comprised of an organosilicon material on said conformal oxide layer by a CVD, PECVD, or spin-on method;
- (d) curing said low k dielectric layer;
- (e) performing a first treatment comprised of a He plasma on said low k dielectric layer in a process chamber to form a transformed low k dielectric layer; and
- (f) performing a second treatment comprised of a H₂ plasma on said transformed low k dielectric layer in a process chamber to form a composite low k dielectric layer comprised of a transformed low k dielectric layer that is enriched in Si-H bonds on a transformed low k dielectric layer that has a mechanically stabilized network of Si-O bonds.

25. (Original) The method of claim 24 further comprised of planarizing said composite low k dielectric layer.

26. (Original) The method of claim 24 wherein said ARC is a TiN layer.

27. (Original) The method of claim 24 wherein the low k dielectric layer is comprised of carbon doped silicon oxide, HSQ, and MSQ and has a thickness between about 1000 and 10000 Angstroms.

28. (Original) The method of claim 27 wherein the low k dielectric layer is a carbon doped silicon oxide layer which is SiCOH with a composition of about 15-18 atomic % Si, about 28-30 atomic % oxygen, about 16-18 atomic % carbon, and about 36-38 atomic % hydrogen.

29. (Original) The method of claim 24 wherein said first and second treatments each include a gas flow rate from about 1500 to 6000 sccm and have a duration from about 10 to 360 seconds.

30. (Original) The method of claim 24 wherein the chamber pressure during said first and second treatments is between about 1 mTorr and 20 Torr.

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31. (Original) The method of claim 24 wherein the He plasma in said first treatment and the H₂ plasma in said second treatment is generated by applying a RF power between about 300 and 2500 Wans.

32. (Original) The method of claim 24 wherein said substrate is heated to a temperature between about 100°C. and 500°C. during said first and second treatments.

33. (Original) The method of claim 24 wherein said transformed low k dielectric layer enriched in Si-H bonds has a thickness from about 1000 to 3000 Angstroms.

34. (Original) The method of claim 24 wherein said first treatment and the second treatment are performed in the same process chamber.

35-52. (Cancelled).